Religion 39 (2009) 34–42

Contents lists available at ScienceDirect

Religion

journal homepage: www.elsevier.com/locate/religion

Are our brains structured to avoid refutations of belief in God? An experimental study

M.A. Persinger

Behavioral Neuroscience Laboratory, Behavioral Neuroscience and Biomolecular Sciences Programs, Laurentian University, Ramsey Lake Road, Sudbury, ON P3E 2C6, Canada

The majority of members of human societies endorse a belief in a Sentient Being or process that is non-physical, invisible, omniscient, and eternal. The belief, which is cognitively separate from experience (Saler, 2001), has a variety of verbal labels that range from a specific God to a more diffuse Great Cosmic Whole. The expectations associated with these beliefs are often entwined with the person's experiences (Pyysiainen, 2001), definition of self, and the often egocentric and ethnocentric assumption of the paramount superiority of the believer's specific form of Sentient Being.

The functional utility of belief in God is demonstrated by its prevalence and persistence in human history (Armstrong, 1993; Comings, 2007; Jordon, 2002). Such consistency in time and space strongly suggests that beliefs in God reflect a property of the human brain and are associated with particular configurations of cerebral activity and cerebral structure (Newberg et al., 2002). One of the most common secular explanations (Persinger, 1987) for the persistence of belief in God is that it reduces the potentially incapacitating anxiety associated with our abilities to anticipate the dissolution of the self: personal death.

Left unchecked, the level of anxiety generated by the implicit verbal statement "I will die", either thought directly or inferred by the observations of others, would be prohibitive to the formation of processes required for complex conceptualization (Persinger, 1985). Any thought sequence that minimizes this anxiety would be reinforced by its consequences. The sequence would be maintained during the person's development and would be elicited in contexts where refutation of the belief might occur.

The prevention of 'awareness' of the challenge that God might not exist to a believer while reading a series of logical statements requires normal cerebral operations that organize the sequence of thoughts before they are cognizant. Hoffman (1986), while studying the disruption of logical thought by schizophrenic patients, reported that discourse planning generally occurs outside the awareness of the normal individual. By the time the person becomes 'aware' of his 'thoughts', they have been filtered, arranged according to grammatical history, and translated to verbal images (Edelman, 1989).

Imaging studies have verified Hoffman's interpretations. For example, Berns et al. (1997) found that even subtle and unperceived changes in the grammatical structure of texts while subjects read passages resulted in distinct changes within the brain in the *absence* of awareness. Increased blood flow, as discerned by positron emission tomography (PET), occurred within the left anterior cingulate and right ventral striatum, while decreases in blood flow were noted more extensively in the dorsolateral prefrontal and parietal areas of the *right* hemisphere. A similar but more extensive pattern of activity within similar regions was observed for Carmelite nuns while they remembered a state of union with God (Beauregard and Paquette, 2006).

Whereas the anterior cingulate is associated with experiences such as personal bonding, egocentric attention, and modulations of anxiety, the right ventral striatum is associated with the unconscious organization of motor sequences in response to stimuli. The right dorsolateral prefrontal regions are strongly coupled to autobiographical memory that defines the uniqueness of the self. Changes in activity within the right parietal region have recently been associated with feelings of information that does not originate from the 'self' (Farrer and Frith, 2002).

Azari et al. (2001) found that religious believers during religious recitations exhibited increased activation of the *right* dorsolateral prefrontal cortices. During this religious state, encouraged by reading a biblical poetic passage (Psalm 23), there was

E-mail address: mpersinger@laurentian.ca

0048-721X/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.religion.2008.05.005

also activation of the dorsomedial frontal cortices in the vicinity of the anterior cingulate region and the right precuneus. The latter is a more medial component of the right parietal lobe.

These authors concluded that religious experiences couched within religious beliefs were a cognitive process mediated by a pre-established neural circuit (Goldman-Rakic, 1988), involving strong anatomical connections between the prefrontal cortices and the medial parietal (precuneus) region. More recent measurements by Kurup and Kurup (2003) have shown that biochemical patterns in spiritually-inclined individuals correlated with *right* hemispheric dominance.

Similar regions were activated in experiments where normal individuals performed moral judgments (Moll et al., 2003). During moral decisions, areas of the prefrontal cortices (particularly the left) and the medial frontal regions were consistently activated. The results supported the existence of a functional connectivity within the frontal polar cortices, the orbitofrontal cortices, the anterior temporal pole and the anterior cingulate gyrus. The latter has been extensively implicated in responding to incongruent stimuli (MacDonald et al., 2000) as well as decision-making, conflict detection, emotional control, and reward tracking.

Elliot and Dolan (1998) showed that hypothesis testing itself, the quintessential procedure of the scientific method, was associated with activation of the left anterior cingulate, right precuneus, and left inferior frontal gyrus. The latter region is involved with the organization of thoughts into articulated sequences. The requirement to *choose* a response was accompanied by activation of the left anterior cingulate and the *right* lateral orbitofrontal cortices. The right orbitofrontal region is strongly involved with mediating the emotional consequences of thoughts or planned actions that have been punished or rewarded by the society and are strongly affected by the social group with which the person affiliates.

This region of the orbitofrontal cortices contains rich reciprocal connections with the amygdala, the primary structure that mediates the experiences of meaning as well as fear, sexuality, and aggression. Healey et al. (1977) found that the person's 'free choice' could be modified by stimulating the right hemisphere with the electromagnetic equivalents of the sound patterns of words. Under these conditions words were 'chosen' according to their emotional dimensions rather than their denotative definition.

The medial prefrontal cortices are consistently activated by theory-of-mind tasks, in which subjects think about their own or other's mental states (Blakemore and Decety, 2001). Damage to or dysfunction of the orbitomedial and polar frontal cortices is frequently associated with acquired sociopathy (Moll et al., 2003). Recent experiments (Koenigs et al., 2007) have shown that the ventromedial prefrontal cortices are necessary for the normal generation of social emotions, in conjunction with normal judgments of right and wrong. People with damage in this area (particularly in the right hemisphere) employ 'utilitarian' judgments for moral dilemmas.

These theoretical models and empirical data suggest that the detection of novel or imminent changes in the direction of a series of semantic implications or meanings may be first discerned by the right hemisphere, before 'left hemispheric' awareness occurs or a 'choice' is made. If the right hemisphere is more specialized for vigilance and affect than the homologous regions of the left hemisphere, then one would expect specific activation by the emotional meaning or implications of statements that challenge personal beliefs, particularly those (such as belief in God) that have maintained reduction of anxiety about the dissolution of the self (death). Spika et al. (1996) have reiterated the importance of religious attributions for countering or improving negative or 'crisis' situations.

There are reciprocal neuronal inhibitions between the homologous regions of the left and right cerebral hemispheres, particularly through the corpus callosum (Hoptman and Davidson, 1994; Schuz and Preissl, 1996). One would expect that either the region or the patterns within the left hemisphere that mediate the awareness of the perceptions that are matched with beliefs would be specifically affected by this right hemispheric detection (Tolaas, 1986). The initial 'perception' by this right hemispheric connection would result in longer periods for cognitive processing. They might be reflected as longer reaction times or, in more qualitative instances, the frank avoidance of the topic. This prediction was consistent with the observations by Binder et al. (1999), who found that perceptual tasks interrupt processes that involve many of the brain areas engaged during semantic retrieval.

The purpose of the first experiment in the present study was to discern if the reaction time to decide if an item was either 'true' or 'false' during a gradual series of items, whose implications approached the conclusion that God did not exist but was a product of the human brain, would increase as the items approached refutation. Because people do not appear to be 'aware' of the implications of their beliefs or the active avoidance of arguments that might refute them, the processes involved with that avoidance should be lateralized to the *right* hemisphere. This assumption is derived from the hypothesis that the sense of self and awareness are primarily linguistic (traditionally left hemispheric) processes (Fischer, 1986).

From the model of vectorial hemisphericity (Persinger, 1993), right hemispheric functions are less associated than are left hemispheric functions with the sense of self and the experience of 'conscious awareness'. Instead the right hemisphere is configured to monitor subtle changes within the environment, particularly visuospatial patterns, meaning, and emotional significance (Budzynski, 1986). This phenomenon, often called 'the hidden observer' effect (Harrington, 1995), is an important component of many of the phenomena associated with suggestibility and hypnotizability (Healey et al., 1996). Electroencephalographic experiments have suggested that novel stimuli are first discerned by right hemispheric processes before they are translated into left hemispheric equivalents of which the person becomes aware (Persinger and Lalonde, 2000).

If this assumption is correct, then people who have less efficient intercalation between the right and left hemispheres would require more time to access the affective component for this process. Consequently, one would predict that reaction times to agree or disagree with a read item (the inference of speed or complexity of cognitive processing) should increase as do the numbers of errors for the left ear during dichotic word listening. Dichotic word listening involves presenting two

different words to each ear simultaneously. Accuracy for the left ear generally reflects speed or accuracy of transfer from the right temporal lobe through the corpus callosum to the left hemisphere (temporal lobe) where awareness of the word occurs. However, there should be no significant correlation between reaction times and errors for the right ear, because most of the auditory information directly accesses the left temporal lobe without involvement of the corpus callosum. That reaction time can reflect the population vector of neuronal assemblies in human beings has been shown by Popivanov et al. (2003).

The purpose of the second experiment was to discern the inflection in the proportion of agreements with items whose content gradually moved towards refutation of the belief that God exists but instead is a product of brain function. There were two predictions. Firstly, as the content approached refutation of God, the proportion of affirmative responses should decrease in a non-linear fashion and exhibit the functional properties of any process approaching a limit or boundary. Secondly, if a temporal gradient was involved that reflected accumulative detection by the right hemisphere, the shared source of variance that was most loaded by the refutation item should also show successively greater loadings by each of the preceding items.

Method

Subjects

In Experiment I, 24 university students (10 men and 14 women) enrolled (years 2000–2001) in a first-year psychology course volunteered as subjects, in exchange for 2% bonus marks that were added to their final grades for the course. In Experiment II, men (28) and women (35) enrolled (2001–2002) in a first-year psychology course served as subjects as a component of class participation. The ages for all but one subject (48 yrs) in both experiments ranged between 19 and 29 years of age. About half the population stated they were Roman Catholic while the others were affiliated with various Protestant denominations. In both experiments the subjects were told that the purpose of the exercise was to discern levels of knowledge.

Procedure

Experiment I

Between December 2000 and February 2001, the students were tested singly during a 60-min period. Each student was first given Roberts' Dichotic Word Listening Task (Roberts et al., 1994). The numbers of errors for the left ear, right ear, and both ears were measured. The subject was then instructed to sit in front of a computer monitor and to respond as quickly as possible with one of two keys to indicate 'true' or 'false' to a series of 33 items. Each item was presented for 6 s.

The items (see Table 1) were designed by the experimenter to produce a slow systematic shift towards a conclusion that God was an experience exclusively generated within the brain. The gradations were intended to allow implicit chains to emerge quickly, such that the inference "God was created by the brain and hence did not exist independent of brain function" might be more easily extrapolated. The items began with basic assumptions concerning the universe. Two items (3 and 9) were included to diminish rapid 'yes' responding at the beginning of the series and to discern the general level of knowledge of the participants.

Experiment II

During a single class setting during December 2001, the subjects were asked to answer 'true' or 'false' to the 33 items (Table 1) that were presented on a single page. The students had also completed Rotton's Paralogic Test (obtained from the author: Dr. J.A. Rotton, Department of Psychology, Florida International University, North Miami, FL 31181) and Tobacyk's Belief Scale (Persinger, 1992; Tobacyk, 1985) Inventory (scores for Total Beliefs and Traditional Religious Beliefs) about three months previously.

Factor analyses (PA method) were completed, despite the large number of variables compared to the sample size, to isolate the items that were most significantly correlated with the response to item 30: "God is produced by activity of neurons". Factor analysis is a mathematical procedure by which the shared source of variance for several variables can be isolated. This shared source of numerical variance is often associated with a common process that is frequently related to a mechanism or causality. If the factor associated with item 30 was responsible for the largest proportion of variance, it was expected to emerge first and to exhibit the largest eigenvalue (an indicator of how many variables could be replaced by the factor). All analyses within both experiments involved SPSS software on a VAX 4000 computer.

Results

Experiment I

The proportion of students who agreed with the item (answered 'yes') and the correlation between the reaction times and the numbers of errors for dichotic word listening for the left ear and right ear are shown in Table 1. The strongest and most statistically significant correlations occurred between the numbers of errors for words presented to the *left* ear (the inference of right hemispheric processing) and the time required to respond to item 27: "All experiences are produced by the brain",

Table 1
Items as they were presented sequentially by computer to the subjects in Experiment I

Item	% Yes	Errors	
		Left ear	Right ear
1. The universe contains matter	100	0.02	0.01
2. The universe contains energy	100	0.19	0.08
3. The universe is 100 years old	0	0.08	0.06
4. Matter is composed of atoms	100	0.32	0.29
5. Atoms interact by energy	94	0.02	0.21
6. Energy cannot be measured	6	0.18	0.22
7. Molecules are composed of atoms	100	0.25	0.32
8. Chemical reactions produce molecular changes	100	0.14	−0.23
9. The basic elements are earth, fire, air, and water	60	0.35	0.35
10. Large molecules, enzymes, influence other molecules	80	0.38	0.28
11. Larger molecules, like DNA, can reproduce themselves	80	0.16	0.26
12. Different properties emerge from different molecules	94	0.37	0.23
13. Cells are made of molecules	83	0.17	0.47*
14. The structure of cells affect their function	94	0.03	0.11
15. Collections of cells compose organs	89	−0.07	−0.51*
16. The human being is composed of organs	94	0.09	0.27
17. The neuron is a cell	77	−0.08	−0.08
18. The brain is composed of neurons	97	0.27	0.04
19. Neurons interact electrically and chemically	97	0.51*	0.32
20. Different interactions produce different behaviors	94	0.20	−0.10
21. All perceptions occur within the brain	63	0.06	0.29
22. All experiences occur within the brain	71	0.29	0.16
23. Beliefs are composed of experiences	94	−0.02	−0.11
24. Most people believe in the existence of God	66	0.02	0.25
25. God is a belief	94	0.10	0.18
26. God is an experience within the brain	43	0.42	0.06
27. All experiences are produced by the brain	60	0.74**	0.32
28. The experience of God is produced by the brain	71	0.44	−0.06
29. God does not exist except within the brain	54	0.16	0.03
30. God is produced by the activity of neurons	60	0.50*	0.13
31. Neurons are composed of large and small molecules	80	0.35	0.15
32. Molecules are composed of atoms	80	0.20	0.14
33. Matter is composed of atoms	97	0.28	−0.04

The first number is the percentage of students who responded 'yes' to the item. The second and third numbers are the correlations (r) between the response time and the numbers of errors during a dichotic word listening test for the left and right ears, respectively.
*$p < 0.05$; **$p < 0.001$.

which occurred about 20 s before the refutation item (item 30). The means, standard deviations and ranges of errors for the left ear, right ear, and both ears were mean = 5.0, SD = 3.1 (1–13), mean = 2.7, SD = 1.5 (1–7), and mean = 1.1, SD = 1.4 (0–5), respectively.

There were increases in the reaction time between item 16 and item 29. Fig. 1 shows the mean reaction times for all 24 subjects for responses to the presentations of items 16 through 29. The correlation coefficient ($r = 0.68$) between the reaction times and the order of the items was statistically significant ($p < 0.01$). The approximate inflection point for the delay in reaction time would have occurred between item 22 ("All experiences occur within the brain") and item 24 ("Most people believe in the existence of God"). The (zero order) correlations between reaction times and polarity (true, false) of the response, reaction time and the order of the item, and the order of the item and the polarity of the response were −0.54, 0.68, and −0.77 (all $p < 0.05$), respectively. There were no statistically significant correlations between the numbers of words in the items and these values for any of these three variables (all $r < 0.27$).

Partial correlations (all df = 10) between the reaction times, serial order of the 33 items and the response of 'true' or 'false' indicated that the correlation between reaction times and the serial order of the items was still statistically significant ($r = 0.49$, $p < 0.05$) when the variance associated with the polarity of the response (true, false) was controlled. When the variance associated with reaction time was controlled, the correlation between the items and the polarity of the responses was −0.66 ($p = 0.01$). As the items approached the refutation statement, the numbers of 'false' responses increased. When the order of the items was controlled, the correlation between reaction times and the polarity of the response (true, false) was not statistically significant ($r = -0.04$).

Further analyses of the coefficients of variation (defined as the standard deviations of the reaction times for all subjects, divided by the means of the reaction times for all subjects, multiplied by 100) indicated that the greatest variation occurred for item 26: "God is an experience within the brain". Regression analysis between the serial order of the item and the coefficient of variation indicated that this measure for item 26 was more than 2 standard deviations greater than the predicted value from the regression equation. There were no statistically significant differences between the Roman Catholic and Protestant groups.

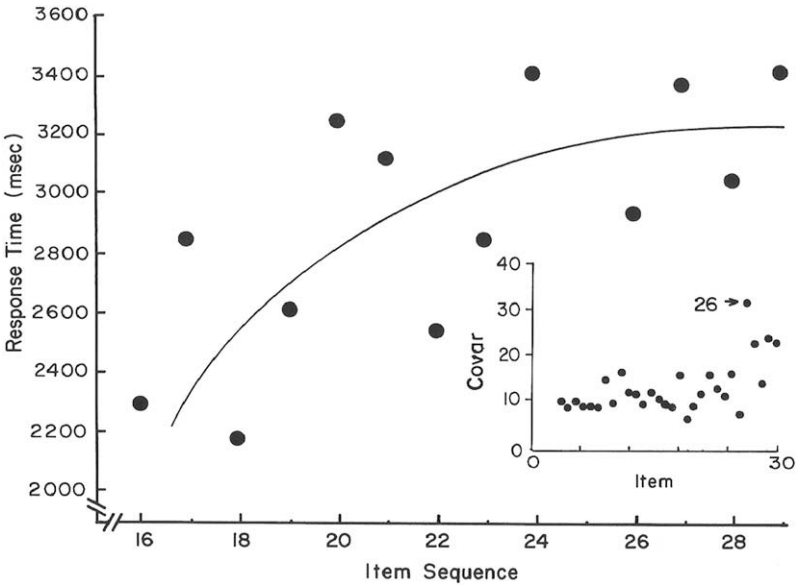

Fig. 1. Mean response times (in ms) for all subjects ($n = 24$) in Experiment I as a function of the sequence of the item containing gradual shifts towards the potential refutation of the existence of God. Inset: Coefficient of variation (covar) for reaction times for the group for each of the 33 items. Note the marked elevation for item 26 ("God is an experience within the brain").

Experiment II

The proportion of all ($n = 63$) subjects who answered 'yes' or its equivalent to items 1 through 30 are shown in Fig. 2. The responses for items 31 through 33 were not included to emphasize the graphic effect. Their percentages were 76%, 97%, and 90%, respectively. With the exception of the item that stated "there are four elements", the responses remained above 75% until item 22. The slope (-3.1, SE $= 1.0$) of the responses between item 22 and item 30 differed significantly from the slope of items (excluding 9 and using 100% - the score for items 3 and 6) between 1 and 21 (-0.2, SE $= 0.2$). Their correlation coefficients (r) were -0.75 ($p < 0.05$) and -0.15 (not significant), respectively. Separate analyses of the Roman Catholic and Protestant subjects did not reveal any statistically significant discrepancies in the strength or direction of the correlations.

The factor analysis extracted 12 factors. However, the first factor (eigenvalue $= 4.66$, explaining 14% of the total variance involving about five adjacent items to the refuting item) to be extracted was loaded significantly ($r = 0.71$) by the refuting item 30: "God is produced by the activity of neurons". The correlations between this factor and the preceding items were item 29, $r = 0.76$; item 28, $r = 0.84$; item 27, $r = 0.28$; item 26 $r = 0.56$; and item 25, $r = 0.39$. Except for item 6, which was negatively loaded ($r = -0.48$), the correlation coefficients for all other items were less than the absolute value of.35

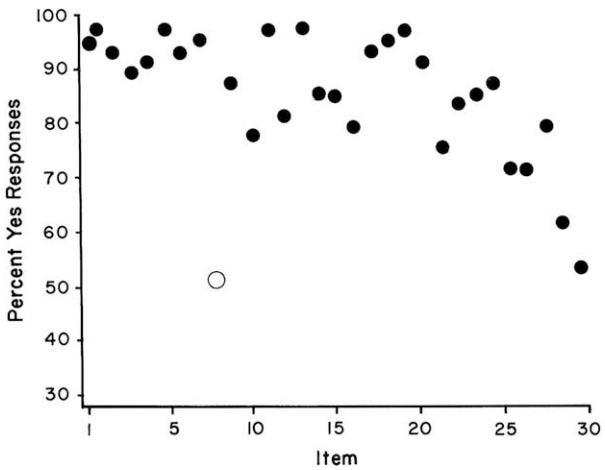

Fig. 2. Percentage of 'yes' responses for 63 subjects in Experiment II, who were presented with the 33 items whose content slowly approached the conclusion that God is produced by the brain. The inverse of items 3 and 6 are shown to maintain homogeneity, For example, only 5% said yes to item 3.

(not significant statistically). This factor was called the God Belief Factor. The mean and standard deviation for the percentage of yes responses for these items, as an aggregate, were 59% and 30%, respectively.

The names of the scales and their means and standard deviations, respectively, employed for the test of the specificity of religious belief and 'reasoning' with the values for the God Belief Factor were Tobacyk's Total Religious Beliefs, 4.8, 1.8; Tobacyk's Total Beliefs, 92.9, 24.3; and Rotton's Paralogic score, 7.6, 2.0. There were statistically significant ($p < 0.05$) associations between the scores for the God Belief Factor and the scores for the degree of agreement with religious beliefs ($r = -0.43$) but not total beliefs ($r = -0.08$) or the paralogic score ($r = 0.23$). In other words, the more the subjects endorsed personal traditional religious beliefs (according to Tobacyk's scale), the more frequently the subjects responded 'false' to the five items preceding and including "God is produced by the activity of neurons". This effect was specific to religious beliefs and not a general propensity to believe ($r = -0.08$) or ability to solve logical problems ($r = 0.23$).

Post hoc exploration indicated that there were significant correlations ($p < 0.05$) between the accuracy of responses to only the normal valid items in Rotton's paralogic scale and the God Belief Factor ($r = 0.34$) and the degree of agreement with religious beliefs ($r = -0.47$). This meant that the more accurately the subjects solved valid logical problems with normal content (vs. exotic content concerning astrology, ESP, and related concepts) the more often they accepted the items leading to and including the refutation statement.

Subjects with more accurate scores for the logical problems with valid content also endorsed traditional religious beliefs with less intensity (-0.47). However, all of these significant correlations were weak and were not of sufficient intensity to assume direct causation, but rather the presence of at least three intervening variables. There were no statistically significant correlations between the other three subsets of items (normal invalid; paranormal valid; paranormal invalid) for the paralogic scale and either the God Belief Factor or religious beliefs.

Partial correlation indicated that the association between the scores for the God Belief Factor and religious beliefs was still significant ($df = 52$, -0.33, $p < 0.01$) after the variance shared by the paralogic score was removed. Initial removal of the shared variance with the scores for the God Belief Factor did not significantly alter the correlation between scores for religious beliefs and the accuracy of the normal valid items of the paralogic score (-0.35, $p < 0.01$). However, removal of the shared variance between the scores for religious beliefs and accuracy for logic *before* the logic scores were correlated with the scores for the God Belief Factor eliminated the statistically significant ($r = 0.18$) association between the two. This meant that the association between logic scores and the God Belief Factor was indirect and was due instead to the central role of the intensity of the subjects' religious beliefs.

Discussion

The results of this study supported the hypothesis that as the organization of verbal stimuli begins to approach the refutation of the belief in God as an independent validity, neurocognitive processes are elicited that may help avoid this conclusion. In the present experiments, psychology students who were not familiar with the purpose of the study displayed a gradual increase in response times to items that began with the assumption that the universe contains matter, and progressed through assumptions such as molecules emerge from atoms, cells emerge from molecules, and different properties are associated with different physical structures. When item content began to require a particular causal assumption that all perceptions and beliefs occur within the brain, a shift towards disagreement began.

The strong correlation between the numbers of errors for the left ear but not the right ear during the dichotic word listening task and the reaction time to item 27, "All experiences are produced by the brain", suggests a 'right hemispheric process' involved with the affective components of implicit verbal chains, as described by Budzynski (1986). This process required about 2 s per person (on average) and occurred about 6 s before the next item: "The experience of God is produced by the brain". This latency is at least two orders of magnitude longer than typical transmission times between the two hemispheres via the corpus callosum.

However, latency in the order of 6 to 20 s is well within the range required for neuroelectrical impulses to spread from the mesial temporal structures (amygdala and hippocampus) in the right hemisphere to these structures in the left hemisphere, if the information was propagated through the dorsal hippocampal commissure (Gloor et al., 1993). This structure, which is located just rostral to the splenium and composes the lower portion of the corpus callosum in a sagittal section, has been suggested (Healey and Persinger, 2001) as a pathway by which information containing strong emotional content within the right hemisphere can be transmitted to the left hemisphere, where appropriate verbal labels or images are associated for semantic retrieval (Binder et al., 1999).

The detection of subtle changes in semantic or grammatical sequences can occur within the brain *without* awareness. Berns et al. (1997) found that reaction time delays as small as 15 ms occurred when shifts in grammar occurred during serial tasks. Although their subjects were unaware of the shifts, there were significant increases in blood flow within the anterior cingulate and right ventral striatum, the same regions suggested by Hoffman (1986) to be involved with the 'unconscious' planning of a thought sequence. It may be relevant that the anterior cingulate, in addition to its role in conflict resolution, decision-making and emotional control, is also strongly involved with the feelings of love and bonding.

The increases in reaction times in the Berns et al. (1997) study were also correlated with decreased blood flow exclusively within the right hemisphere at the level of the dorsal prefrontal cortices, and at the junction of the inferior lobule of the parietal lobe and the superior temporal gyrus. These regions have been implicated in the control of 'unconscious' behaviors as well as the monitoring of the person's beliefs. Beliefs from a behavioral perspective can be defined as the brain's self-imposed

response to and the resultant organizations and attributed meanings of the myriad verbal images that occupy the recursive recreation of consciousness approximately every 15–30 ms (Joliot et al., 1994; Llinas and Ribary, 1993; Poppel, 1996).

A prominent involvement of a right hemispheric process might explain the 'hypervigilant' and emotional aspects of beliefs, particularly when their validity is challenged. A right hemispheric source within the junction between the temporal and parietal lobes might also explain the historical association between experiences involving large extrapersonal (allocentric) spatial relationships and Sentient Beings. These spaces, within which the experient's diminutive stature is enhanced, range from large cathedrals to the star canopy.

That the experiences of Sentient Beings (the sensed presence) are the awareness of the right hemispheric equivalent of the left hemispheric sense of self has been suggested previously (Persinger, 1993), and has been supported experimentally (Cook and Persinger, 2001; Persinger and Healey, 2002). Similar experiences have been reported by patients whose amygdalas were surgically stimulated (Ardila and Gomez, 1988) or during religious reveries (Newberg et al., 2002). This same structure is activated in response to aversive stimuli mediated through language, by the evaluation of outcomes, and during subliminal perception (Moll et al., 2003).

We (St-Pierre and Persinger, 2006) have found that stimulation of the right hemisphere by application of weak, complex magnetic fields at the level of temporoparietal lobes produced a sensed presence in about 80% of normal volunteers. Individuals with more frequent experiences classically attributed to elevated temporal lobe activity within the right hemisphere describe more elaborate and personally profound 'Sentient Beings' than those exposed to sham fields. Women, who generally show greater interhemispheric coherence for the temporoparietal regions, reported these experiences more frequently than did men (Persinger, 2003). For men these experiences were loaded on the same factor as felt 'intrusions' from extrapersonal or ego-alien sources. For women these experiences were loaded on the same factor as dizziness, fear, and out-of-body experiences.

Kurup and Kurup (2003) found that people who engaged in daily living of spirituality that emphasized these beliefs displayed blood chemistry typical of right hemispheric dominance. These researchers found that spiritually-inclined individuals, relative to atheistic individuals, exhibited increased serum levels of serotonin, quinolinic acid, and nicotine, but decreased levels of dopamine, noradrenaline, and morphine. Increased levels of serotonin encourage normal mood, while nicotinic cholinergic stimulation can facilitate vigilance. Diminished levels of dopamine and morphine suggest that spiritual beliefs, particularly rituals, can replace the requirement for addictive substances.

From this perspective, the more dramatic association between sudden religious conversions (and the reduction of psychological depression) and temporal lobe epilepsy with primarily right-sided foci, described by Dewhurst and Beard (1970), might be considered an extension of normal processes, rather than manifestations of pathological, psychotic, or extremely aberrant brain functions. On the other hand, inhibition of the left temporoparietal junction (Samson et al., 2004) from overstimulation of the right temporoparietal region, one of the most common correlates of both the Sensed Presence and mystical experiences, could adversely affect the reasoning regarding the beliefs of others.

Cognitive images, manifested as visual forms, voices, or altered body schema (the sensed presence) not concordant with concurrent cognitive goals may be experienced as originating from 'non-self' sources (Hoffman, 1986). If the cognition is fragmented, such as during the manifestations of schizophrenia, the attributions for these 'non-self' experiences may appear bizarre and egocentric. The patient might conclude that he or she is God or a related deity. However, if the functions of the prefrontal and temporal lobes are intact, then the etiology of the sensed presence would be more likely to be attributed to cultural deities.

One would predict that the auditory experiences attributed to God 'revealing' hidden or cosmic information, during periods when the experient has been privately challenging the existence of God, might be considered a natural form of negative feedback or homeostasis. The neuroelectrical process associated with the experience might block any further inferential sequence, whose endpoint would have been the conclusion that God does not exist. Consequently, these anxiogenic conditions of refuting the belief, on which one's immortality is dependent, would be avoided. These singular events would be equivalent to points of bifurcation that would determine people's behavior for the rest of their lives. In 'retrospect', or during the reconstruction of autobiographical memory, which primarily involves integrated right prefrontal functions, the person might conclude that he or she was 'chosen' or 'directed' for a particular career.

The positive correlation between errors for the left ear and the time to respond to the items might indicate a general decreased proficiency of this right temporal lobe function, or anomalous speeds of intercalation between the left and right temporal lobes through the corpus callosum. One might argue that this lower proficiency unmasked the location of this neuroprocess, similar to the procedure of overloading the input into a defective computer system in order to discern which components are less than optimal for the speed of processing.

It may be relevant that item 26, "God is an experience within the brain", immediately antecedent to the item most correlated with the numbers of errors in the left ear, was also associated with the greatest coefficient of variation for the whole group's reaction time. If we assume that the characteristics of a group response reflect the variations of the individual over time, then this conspicuous variability might reflect the initiation of the right hemispheric inferential process. This would mean that the increasing 'gradient' of the avoidance of the aversive consequences of the refutation of the belief would have begun about four items (in the order of 20 s) before this blatant conclusion.

Items 25 and 26 were also the first two of five items that preceded the refuting item and loaded on a single factor. The significant correlations between the intensities (as inferred by the degree of agreement on a questionnaire) of religious beliefs (but not of general beliefs) and the subjects' agreements to the mean score for the cluster of these five items support the

validity of the direction of the responses. People who stated that they believed more strongly in traditional religious statements from a questionnaire (given about 3 months previously) were more likely to state 'false' to the items whose content gradually implied that God was an artifact of brain activity. There was no difference between their affiliation as Roman Catholics or Protestants.

The partial correlation analyses indicated that a person's accuracy for logical extrapolation for only the normal valid items was significantly but inversely related to their endorsement of religious beliefs. The observation that the scores for normal invalid items, paranormal valid items, or invalid paranormal items were not correlated significantly with religious beliefs or with the response to the sequential items may suggest that a specific class of linguistic or neurocognitive processes may be involved with the formation and maintenance of religious beliefs. One candidate for this class would be counterintuitive representations involving a conscious agent (Pyysiainen et al., 2003). This might explain why people who endorsed more intense religious beliefs were less accurate for items with normal valid content.

The results of these experiments are also congruent with the clinical observations of this experimenter. Educated individuals, often employed as lawyers, physicians, judges, professors, and scientists (vocations that allegedly emphasize logic and rationality) often believe in God or some secular variant such as 'Mathematical Order' or 'The Origin of Celestial Order'. As suggested by Masserman (1973), these propensities may be an intrinsic component of our evolution. When systematic questions are employed to challenge this belief, these individuals frequently agree with the successive statements until the content approaches about two to four statements before the belief might be refuted. At this juncture the person's verbal behavior (and presumably cognitive activity) deviates suddenly to another topic or abrupt emotional behavior is displayed such as "I know what I know" or "you must have faith". Interestingly, they exhibit the same pattern as people who, when challenged, believe they have been visited by aliens or 'other-dimensional' creatures (Persinger, 2000).

Obviously, this research does not prove whether God exists or not, because the question is, at least from the perspective of scientific methodology, an empty hypothesis. However, the adherence to the belief that God exists by the majority of human beings has been associated with a history of war and mass homicides (Persinger, 1987, 1997). A significant proportion of normal, educated men and women who attend church regularly and who reported elevated temporal lobe experiences state that they would kill in God's name if He told them to do so (Buckman, 2002).

That a belief in 'some type' of God must have adaptive utility has never been examined by the scientific method. The frequent presumption that affiliation with one of the myriad of religious organizations, each purporting to exclusively access the validity of this belief, is beneficial for humanity has never been verified. Human history has been replete with cases of peoples being marginalized, excluded, subjugated, or killed simply because they did not believe in the same God. Until the neurocognitive processes and multiple neuroanatomical pathways can be isolated, understood, and controlled, the God belief should be considered the source of potentially dangerous human behaviors.

Acknowledgments

Thanks to Stanley Koren, Sandra Tiller, and Linda St-Pierre for technical assistance.

References

Ardila, A., Gomez, J., 1988. Paroxysmal 'feeling of somebody being nearby'. Epilepsia 29, 188–189.
Armstrong, K., 1993. A history of God. Ballantine Books, New York.
Azari, N.P., Nickel, J., Wunderlich, G., Niedeggen, M., Hefter, H., Tellmann, L., Herzog, H., Stoerig, P., Birnbacher, D., Seitz, R.J., 2001. Neural correlates of religious experiences. European Journal of Neuroscience 13, 1649–1652.
Beauregard, M., Paquette, V., 2006. Neural correlates of a mystical experience in Carmelite nuns. Neuroscience Letters 405, 186–190.
Berns, G.S., Cohen, J.D., Mintun, M.A., 1997. Brain regions responsive to novelty in the absence of awareness. Science 27, 1272–1275.
Binder, J.R., Frost, J.A., Hammeke, T.A., Bellgowan, P.S.F., Rao, S.M., Cox, R.W., 1999. Conceptual processing during the conscious resting state: a function MRI study. Journal of Cognitive Neuroscience 11, 80–93.
Blakemore, S.-J., Decety, J., 2001. From the perception of action to the understanding of intention. Nature Reviews Neuroscience 2, 563–567.
Buckman, R., 2002. Can we be good without god? Prometheus, New York.
Budzynski, T.H., 1986. Clinical applications of non-drug-induced states. In: Wolman, B.B., Ullman, M. (Eds.), Handbook of States of Consciousness. Van Nostrand, New York, pp. 428–460.
Comings, D.E., 2007. Did Man Create God? Hope Press, Duarte, CA.
Cook, C.M., Persinger, M.A., 2001. Geophysical variables and behavior: XCII. Experimental elicitation of the experience of a sentient being by right hemispheric, weak magnetic fields: interactions with temporal lobe sensitivity. Perceptual and Motor Skills 92, 447–448.
Dewhurst, K., Beard, A.W., 1970. Sudden religious conversions in temporal lobe epilepsy. British Journal of Psychiatry 117, 497–507.
Edelman, G.M., 1989. The remembered present: a biological theory of consciousness. Basic Books, New York.
Elliot, R., Dolan, R.J., 1998. Activation of different anterior cingulate foci in association with hypothesis testing and response selection. Neuroimage 8, 17–29.
Farrer, C., Frith, C.D., 2002. Experiencing oneself versus another person as being the cause of action. Neuroimage 15, 596–603.
Fischer, R., 1986. Toward a neuroscience of self-experience and states of self-awareness and interpreting interpretations. In: Wolman, B.B., Ullman, M. (Eds.), Handbook of States of Consciousness. Van Nostrand, New York, pp. 3–30.
Gloor, P., Salanova, V., Olivier, A., Quesney, L.F., 1993. The human dorsal hippocampal commissure. Brain 116, 1249–1273.
Goldman-Rakic, P.S., 1988. Topography of cognition: parallel distributed networks in primate association cortex. Annual Review of Neuroscience 11, 137–156.
Harrington, A., 1995. Unfinished business: models of laterality in the nineteenth century. In: Davidson, R.J., Hugdahl, K. (Eds.), Brain Asymmetry. MIT Press, Cambridge, MA, pp. 3–27.
Healey, F., Persinger, M.A., 2001. Experimental production of illusory (false) memories in reconstructions of narratives: effect size and potential mediation by right hemispheric stimulation from complex, weak magnetic fields. International Journal of Neuroscience 106, 195–201.
Healey, F., Persinger, M.A., Koren, S.A., 1996. Enhanced hypnotic suggestibility following application of burst-firing magnetic fields over the right temporoparietal lobes: a replication. International Journal of Neuroscience 87, 201–207.

Healey, F., Persinger, M.A., Koren, S.A., 1997. Control of choice by application of electromagnetic field equivalents of spoken words: mediation by emotional meaning rather than linguistic dimensions? Perceptual and Motor Skills 85, 1411–1418.
Hoffman, R.W., 1986. Verbal hallucinations and language production processes in schizophrenia. The Behavioral and Brain Sciences 9, 503–548.
Hoptman, M.J., Davidson, R.J., 1994. How and why do the two cerebral hemispheres interact? Psychological Bulletin 116, 195–219.
Joliot, M., Ribary, U., Llinas, R., 1994. Human oscillatory brain activity near 40 Hz coexists with cognitive temporal binding. Proceedings of the National Academy of Sciences USA 91, 11748–11751.
Jordon, M., 2002. Encyclopedia of Gods. Kyodo Printing, Singapore.
Koenigs, M., Young, L., Adolphs, R., Tranel, D., Cushman, F., Hauser, M., Damasio, A., 2007. Damage to the prefrontal cortex increases utilitarian moral judgements. Nature 446, 908–911.
Kurup, R.K., Kurup, P.A., 2003. Hypothalamic digoxin, hemispheric chemical dominance, and spirituality. International Journal of Neuroscience 113, 383–393.
Llinas, R., Ribary, U., 1993. Coherent 40-Hz oscillation characterizes dream state in humans. Proceedings of the National Academy of Science USA 90, 2078–2081.
MacDonald, A.W., Cohen, J.D., Stenger, V.A., Carter, C.S., 2000. Dissociating the role of the dorsolateral prefrontal and anterior cingulate cortex in cognitive control. Science 288, 1835–1838.
Masserman, J., 1973. Therapy of Personality Disorders, second ed. Wm. C. Brown, Dubuque, IA, pp. 28–29.
Moll, J., de Oliveira-Souza, R., Eslinger, P.J., 2003. Morals and the human brain: a working model. Neuroreport 14, 299–305.
Newberg, A., D'Aquili, E., Rause, V., 2002. Why God Won't Go Away. Random House, New York.
Persinger, M.A., 1985. Death anxiety as a semantic conditioned suppression paradigm. Perceptual and Motor Skills 60, 827–830.
Persinger, M.A., 1987. Neuropsychological bases of God Beliefs. Praeger, New York.
Persinger, M.A., 1992. Criterion validity for Rotton's paralogic test: beliefs of forbidden knowledge may negatively affect inferential problem solving. Perceptual and Motor Skills 74, 1027–1030.
Persinger, M.A., 1993. Vectorial hemisphericity as differential sources for the sensed presence, mystical experiences, and religious conversions. Perceptual and Motor Skills 76, 915–930.
Persinger, M.A., 1997. "I would kill in God's name": role of sex, weekly church attendance, report of a religious experience, and limbic lability. Perceptual and Motor Skills 85, 128–130.
Persinger, M.A., 2000. The UFO experience: a normal correlate of human brain function. In: Jacobs, D.M. (Ed.), UFO Abductions: Challenging the Borders of Knowledge. University Press of Kansas, Lawrence, pp. 262–302.
Persinger, M.A., 2003. The sensed presence within experimental settings: implications for the male and female concept of self. The Journal of Psychology 137, 5–16.
Persinger, M.A., Healey, F., 2002. Experimental facilitation of the sensed presence: possible intercalation between the hemispheres by complex magnetic fields. Journal of Nervous and Mental Disease 190, 533–541.
Persinger, M.A., Lalonde, C.-A., 2000. Right to left hemispheric shift in occipital electroencephalographic responses related to Kimura figures. Perceptual and Motor Skills 91, 273–278.
Popivanov, D., Janyan, A., Andonova, E., Stamenov, M., 2003. Common dynamic properties of biosignals during cognition: self-similarity and chaotic dynamics of both response times and EEG during movement imagery. Nonlinear Dynamics, Psychology, and Life Sciences 7, 315–328.
Poppel, E., 1996. Reconstruction of subjective time on the basis of hierarchically organized processing systems. In: Pastor, M.A., Artieda, J. (Eds.), Time, Internal Clocks and Movement. Elsevier, New York, pp. 165–183.
Pyysiainen, I., 2001. Cognition, emotion, and religious experience. In: Andresen, J. (Ed.), Religion and Mind: Cognitive Perspectives on Religious Belief, Ritual, and Experience. Cambridge University Press, Cambridge, pp. 70–93.
Pyysiainen, I., Lindeman, M., Honkela, T., 2003. Counterintuitiveness as the hallmark of religiosity. Religion 33, 341–355.
Roberts, M.A., Persinger, M.A., Grote, C., Evertowski, L.M., Springer, J.A., Tuten, T., Moulden, D., Franzen, K.M., Roberts, R.J., Baglio, C.S., 1994. The dichotic word listening test: preliminary observations in American and Canadian samples Applied Neuropsychology, 1, 45–56.
Saler, B., 2001. About what we may believe about beliefs. In: Andresen, J. (Ed.), Religion in Mind: Cognitive Perspectives on Religious Belief, Ritual, and Experience. Cambridge University Press, Cambridge, pp. 47–69.
Samson, D., Apperly, I.A., Chiavarino, C., Humphreys, G.W., 2004. Left temporoparietal junction is necessary for representing someone else's belief. Nature Neuroscience 7, 499–500.
Schuz, A., Preissl, H., 1996. Basic connectivity of the cerebral cortex and some considerations on the corpus callosum. Neuroscience and Biobehavioral Reviews 20, 567–570.
Spika, B., Ladd, K.L., Macintosh, D.N., Milmoe, S., 1996. The content of religious experience: the roles of expectancy and desirability. International Journal of Psychology and Religions 6, 95–105.
St-Pierre, L.S., Persinger, M.A., 2006. Experimental facilitation of the sensed presence is predicted by specific patterns of applied magnetic fields not by suggestibility: re-analyses of 19 experiments. International Journal of Neuroscience 116, 1–18.
Tobacyk, J., 1985. Paranormal beliefs, alienation, and anomie in college students. Psychological Reports 57, 844–846.
Tolaas, J., 1986. Transformatory framework: pictorial to verbal. In: Wolman, B.B., Ullman, M. (Eds.), Handbook of States of Consciousness. Van Nostrand, New York, pp. 31–67.

Michael A. Persinger is a behavioral neuroscientist who is a Full Professor of Psychology and Biology and a member of the Biomolecular Sciences Program at Laurentian University. Over the last 40 years he has published over 300 technical papers and chapters and several books in the general area of integrative neurosciences, with particular emphasis upon the significance of anomalous experiences and their contributions from natural environmental sources. Working on the assumption that all experiences are correlated with brain structure and function, he has been pursuing the quintessential metaphysical problems of 'what really exists?' and the methodological feasibility of a science of ultimate reality.